MEXICAN CLIMATOLOGICAL DATA.

Through the kind cooperation of Señor Manuel E. Pastrana, Director of the Central Meteorologic-Magnetic Observatory, the monthly summaries of Mexican data are now communicated in manuscript, in advance of their publication in the Boletin Mensual. An abstract, translated into English measures, is here given, in continuation of the similar tables published in the MONTHLY WEATHER REVIEW since 1896. The barometric means have not been reduced to standard gravity, but this correction will be given at some future date when the pressures are published on our Chart IV.

Mexican data for March, 1900.

Stations.	Altitude.	Mean barometer.	Temperature.			Relative humidity.	Precipitation.	Prevailing direction.	
			Max.	Min.	Mean.			Wind.	Cloud.
	Feet.	*Inch.*	*°F.*	*°F.*	*°F.*	%	*Inch.*		
Culiacán Rosales (Sinaloa)	112	29.74	90.5	61.7	74.5	58	0.99	n. e.	....
Durango (Seminario)	6,243	24.01	82.4	36.0	59.5	52	1.40	sw.	w.
Leon (Guanajuato)	5,934	24.28	83.1	41.2	62.1	47	0.74	ssw.	sw.
Merida	50	29.94	102.6	54.0	77.2	59	1.65	se.	n.
Mexico (Obs. Cent.)	7,472	23.04	78.8	39.6	60.6	45	0.63	nw.	sw.
Morelia (Seminario)	6,401	23.96	78.1	43.7	61.5	55	1.17	s.	wsw.
Puebla (Col. Cat.)	7,112	23.36	78.4	41.0	63.5	49	0.01	e.	sw.
Puebla (Col. d. Est.)	7,118	23.33	79.7	41.2	62.2	48	0.06	ene.	sw.
Queretaro	6,070	24.19	80.2	44.1	61.9	52	1.31	e.	w.
Saltillo (Col. S. Juan)	5,399	24.74	78.8	37.2	59.4	69	2.65	s.	sw.
San Isidro (Hac. de Guanajuato)	......	......	73.4	55.4	......	......	1.29	w.	....
Silao	6,063	24.26	78.4	48.4	64.8	52	0.84	se.	w.
Zacatecas	8,015	22.50	77.0	35.6	53.8	52	2.41	sw.	e., se.

RECENT PAPERS BEARING ON METEOROLOGY.

W. F. R. PHILLIPS, in charge of Library, etc.

The subjoined list of titles has been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau:

La Nature. Paris. 28me Année.
L. D. La périodicité dans les phénomènes météorologiques. P. 275.
Archives des Sciences Physiques et Naturelles. Genève. 4 Période. Tome 9.
Gautier, R. Observations météorologiques faites aux fortifications de Saint-Maurice pendant l'année 1898, résumé. P. 209.
Das Wetter. Berlin. 17 Jahrg.
Meinardus, W. Ueber die Methoden der maritimen Klimatologie. (Schluss). P. 49.
Assmann, R. Die Sonnenstrahlung. P. 54.
Petermann's Mitteilungen. Gotha. 46 Band.
Stahl, A. F. Teheran und Umgegend, Klima. P. 51.
La Nature. Paris. 28me Année.
Plumandon, J. R. L'évolution des cumulus. P. 297.
L'Aerophile. Paris. 8me Année.
B. P. Notice sur la télégraphie sans fil au moyen des ondes Hertziennes. P. 33.
Gaea. Leipzig. 36 Jahrg.
Klein, H. J. Wetterprognosen auf mehrere Tage und die täglichen Wetterkarten. P. 257.
Ciel et Terre. Bruxelles. 21me Année.
Rocquigny, G. de. Les orages en février dans le centre de la France. P. 66.
Sitzungsberichte der kaiserlichen Akademie der Wissenschaften. Berlin. Band. 16.
Ladenburg, A. and Krugel, C. Uber das Krypton. P. 212.
Aeronautical Journal. London. Vol. 4.
—— Lord Rayleigh on "Flight." P. 113.
Smyth, D. M. B. A Theory of Flight. P. 120.
Journal de Physique. Paris. 3me série. Tome 9.
Sagnac, G. Théorie nouvelle de la transmission de la lumière dans les milieux en repos ou en mouvement. P. 177.

Meteorologische Zeitschrift. Wien. Band 17.
Bjerknes, V. Das dynamische Princip der Cirkulationsbewegungen in der Atmosphäre. P. 97.
Bergholz, P. Die Ergebnisse der Beobachtungen der Wolken in Manila in dem internationalen Wolkenjahre. P. 106.
Woeikof, A. Mitteltemperaturen von Ostsibirien. P. 116.
—— Ueber das Hagelschiessen. P. 125.
Polis, P. Ergebnisse der Beobachtungen von Feuchtigkeit und Bewölkung zu Aachen 1873–1897. P. 128.
Trabert, Wilh. Nachträgliche Bemerkung zu dem Referate über die Versuche von Pellat. P. 129.
MacDowall, Alex. B. Gibt es eine zehnjährige Wetterperiode? P. 130.
—— Die Kanonen von Barisal. P. 131.
Hann, J. Resultate der meteorologischen Beobachtungen in British-Nordamerika im Jahre 1898. P. 132.
—— Meteorologische Beobachtungen in Deutsch-Neu Guinea. P. 133.
—— Charles Rabot über Gletscherschwankungen in den arktischen und hochnordischen Gegenden überhaupt. P. 135.
Gruhn, —. Dauer des Sonnenscheins in Meldorf, verglichen mit Hamburg. P. 135.
Hellmann, G. Ueber die Auswerthung der Aufzeichnungen selbstregistrirender Regenmesser.
—— Temperaturmittel für Süd-Afrika. P. 137.
—— Zum Klima des arktischen Nordamerika. P. 139.
—— Hörbarkeit des Schalles in der Luft. P. 139.
Nature. London. Vol. 61.
Aitken, John. Atmospheric Electricity. P. 514.

A PARTIAL EXPLANATION OF SOME OF THE PRINCIPAL OCEAN TIDES.[1]

By R. A. HARRIS, of the United States Coast and Geodetic Survey.

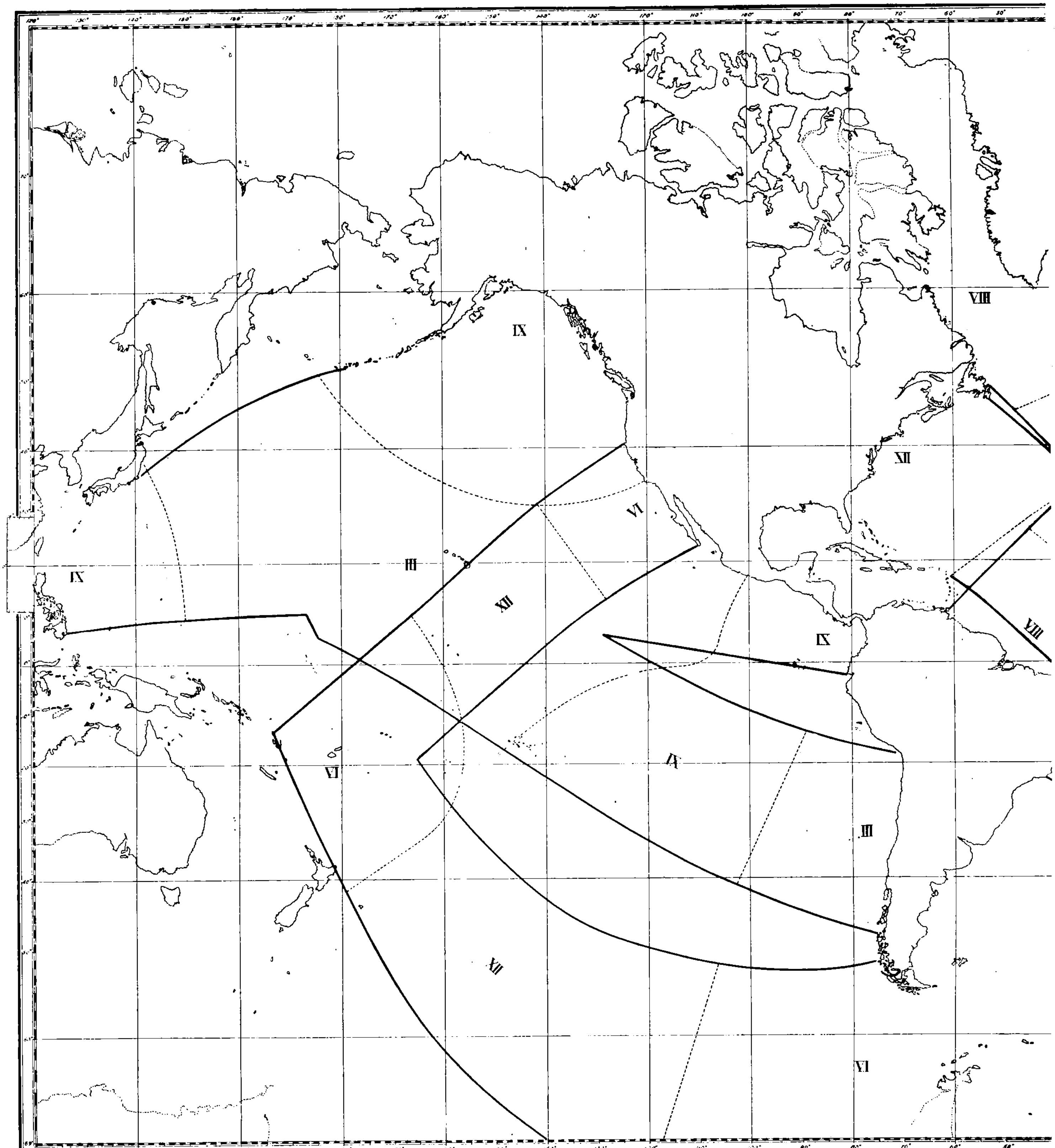
The object of this paper is to state in as brief a manner as possible some of the conclusions reached by the writer respecting the causes of the tides. Owing to the omission of details, the treatment here given will necessarily be very incomplete. The original paper, now in preparation, from which the matter for the present one is abstracted, will appear as an appendix to the Report of the United States Coast and Geodetic Survey for the year 1899–1900.

In approaching the question of the actual causes of the tides, upon which so much labor has been expended and concerning which so much has been written, one may well surmise that the subject does not admit of accurate or complete treatment. It is therefore natural to consider, in the first place, only those sources which would seem to account for the dominant tides in any given region under consideration, and to postpone, perhaps indefinitely, the consideration of those sources whose importance in the production of tides must be relatively small. Considering the actual distribution of land and water, a few computations upon hypothetical cases will suffice to convince one that as a rule the ocean tides, as we know them, are so great that they can be produced only by successive actions of the tidal forces upon oscillating systems each having, as free period, approximately the period of the forces, and each perfect enough to preserve the general character of its motion during several such periods were the forces to cease their action. This greatly simplifies matters. For, having once for all constructed a set of force diagrams for the various latitudes, we have only to discover those regions which have a free period of oscillation about equal to the period of the forces, and to then ascertain at what time the particles should be at elongation in their nearly rectilinear paths. The paths of the particles being practically fixed and determined by the boundary conditions, it becomes possible to disregard the forces arising from the earth's rotation and which vary with the component velocities of the moving particles.

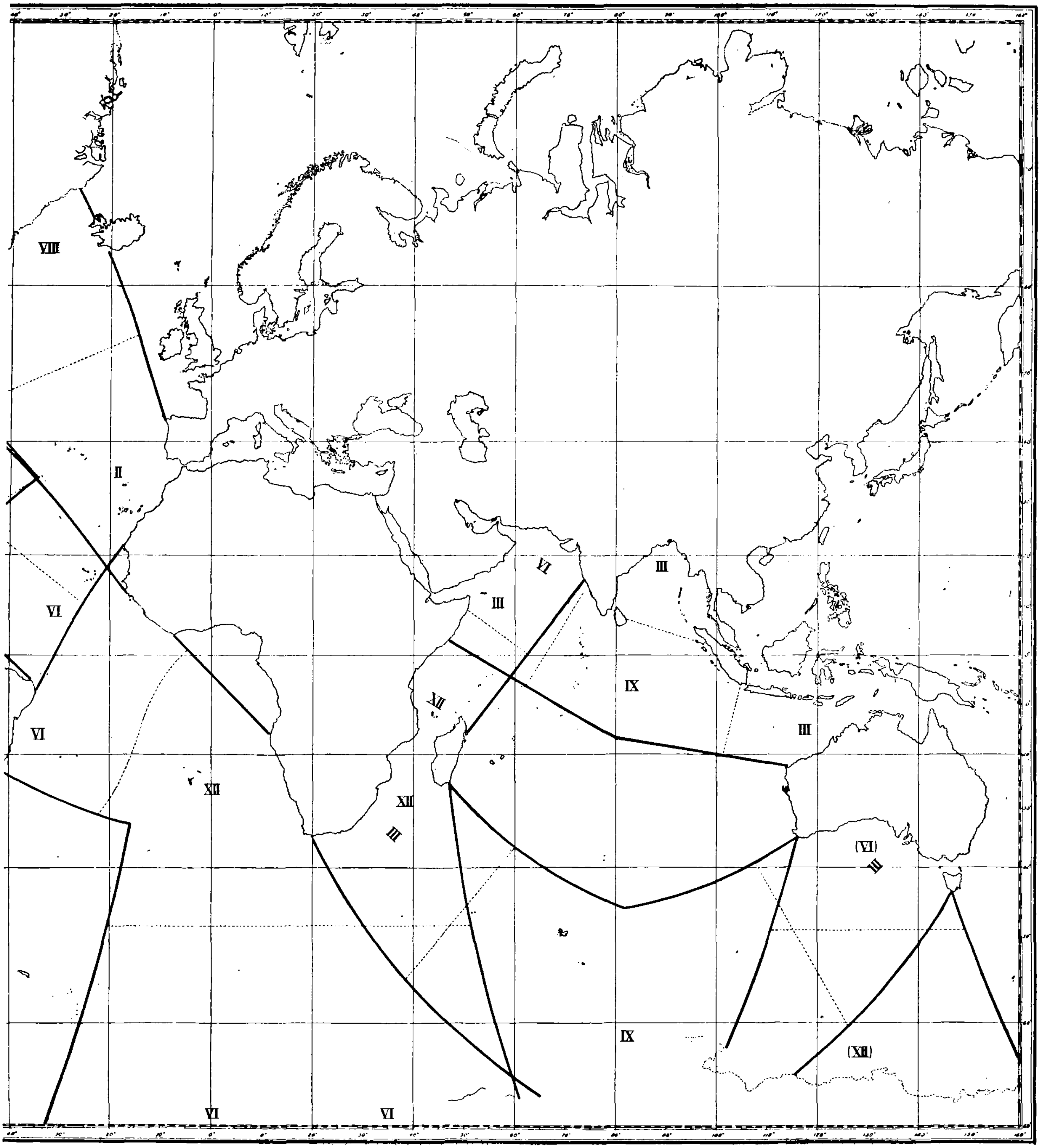
Since some of the natural boundaries of any oceanic region may be indefinite, imperfect, or altogether wanting, serious

[1] Read before the National Academy of Sciences, April 19, 1900.

SYSTEMS FOR THE



SEMIDIURNAL TIDES.



difficulties arise when we attempt to actually mark out areas or systems of areas which shall have the required period of free oscillation, and in which it is possible for the tidal forces to incite a considerable tide. This is believed to be the first attempt to approximately locate areas which seem to account for the principal ocean tides, having regard to the difficulties just referred to, and to connect the possible motions of the water with the tidal forces.

The writings of Plato, Galileo, Newton, Bernoulli, Euler, Young, and Fitz Roy show that these philosophers regarded nearly free oscillations of large bodies of water, oscillations analogous to vibrations of pendulums, as important factors in causing or modifying the tides. Their ideas regarding the requirements of such motions were somewhat confused. Airy is the first writer who treats, with success, stationary waves under several conditions. Ferrel's treatment of tides in east-and-west canals, closed at both ends, is of special importance. He suggests that the large semidiurnal tides of the North Atlantic are due mainly to an east-and-west oscillation of its northern portion. In Chapters VIII and XI of his Hydrodynamics, Lamb gives an excellent treatment of forced and free oscillations. Chapters III–V of Rayleigh's Theory of Sound; and Chapters IX and VII, Vols. I and II, of Routh's Dynamics, have an important bearing upon the subject.

For brevity's sake, the statements which follow will generally be made without special reference to the diurnal wave, although some of them naturally apply to it as well as to the semidiurnal.

By *oscillating area* we shall usually mean an area comparatively simple in form whose free period of oscillation, were its boundaries all rigid, would not differ much from twelve lunar hours.

All areas which oscillate together because of contiguity or overlapping, form an *oscillating system.*

The division of the principal part of the ocean's surface into a few systems is not arbitrary; whether or not we shall suppose these systems divided into more simple regions styled "areas" is a matter of expediency to be decided by the purpose in hand.

Generally areas partially inclosed by land resemble more or less an approximate rectangle, a right trapezoid, or a triangle. Areas having, or resembling, either of the first two forms may be styled *simple* or *canal-like.*

A fractional oscillating area is an area having an oscillation but which could not, because of its dimensions, oscillate in the required period were it completely surrounded by rigid walls.

The forces are connected with the dominant ocean tides through the following rule applied to an area or to a system of areas, as the case may be:

If to the particles of water in a given oscillating system, each area of uniform depth, and wherein the resistances are proportional to the velocities of the particles, a series of simple harmonic forces having for period the free period of the body of water be applied and a permanent state established, then must the time of elongation be simultaneous with the time when the virtual work of the external periodic forces upon the system becomes zero.

In a canal-like landlocked sea whose length is less than $\frac{1}{2}\lambda$, i. e., a half wave length, although too long for approximately obeying the corrected equilibrium theory, the canal theory still applies, and the tides may be sensible. If this same body were less landlocked, the tide would be dissipated to a considerable extent, and would no longer be as large as before. Such cases can then be neglected, and only areas quite close to $\frac{1}{2}\lambda$ (or a multiple of it) in (virtual) length need be considered. Hence, according to the above rule, the times of elongation for the dominant tides of the ocean can not depart much from the time when the virtual work upon the system becomes zero.

Representing the semidaily tidal forces at a given latitude by radiating arrows, the extremities will define an ellipse. At the equator the ellipse becomes a straight line running east and west; at either pole it is a vanishing circle. The arrows are numbered clockwise for the Northern Hemisphere, and counter-clockwise for the Southern Hemisphere. The arrow pointing east represents the force three hours before the time of transit and is numbered 9; the arrow pointing west represents the force three hours after the time of transit and is numbered 3.

To apply the above rule to an oscillating system in nature, we imagine the force diagrams to be scattered along the lines of motion of the areas of the system, e. g., along the axis of a canal-like body of water. Let us begin with any Greenwich component hour. The local component hour corresponding to the numbering on the force diagram is found by subtracting the longitude in time from the assumed Greenwich hour if the longitude be west, and adding the longitude if it be east. Project the force arrow belonging to the assumed time in each diagram upon the line of motion passing through it. The aggregate of the elementary masses each multiplied by the intensity of the tidal force in the direction of the displacement of the element, and again by quantity proportional to the value of the maximum displacement (since the oscillation is harmonic), must be zero at the time of high or low water.

In some simple cases the results can be seen at once. We thus have the following:

In an east-and-west canal half a wave length long it is high water at the east end at the component hour 0 or 12, the time meridian being understood to be the meridian of the middle point of the canal.

In an east-and-west canal one wave length long it is high water at both ends at the component hour —3 or 9.

In a meridional canal half a wave length long it is high water at the south or north end, according as the greater part of the canal lies north or south of the equator, at the component hour 3.

In a meridional canal one wave length long, whose center lies between 45° south and 45° north latitude, it is high water at both ends at the component hour 9; if the center lies beyond these limits, the component hour of high water at the ends is 3.

Before attempting to point out possible oscillating areas one should establish certain lemmas pertaining to the motion in question. A few are given here, and these usually without reference to the reasoning or experience upon which they depend:

1. Generally, with such initial displacements as are likely to occur in nature, a landlocked body of water has one (proper) period of (free) oscillation, and perhaps several such periods; this is evidenced by the phenomenon of the seiches.

2. When the two straight ends constitute the only rigid portion of the boundary, the width of the area should be at least about $\frac{1}{4}\lambda$ in order to produce a sensible stationary wave. It should be still wider if the length be a multiple of $\frac{1}{2}\lambda$.

3. If one side wall of the canal be land, then the necessary width is only one-half as great as in the preceding case.

4. The virtual length of a right trapezoidal area is approximately its mean geometrical length.

5. A tapering or narrowing toward the end of a canal increases the frequency of oscillation, i. e., the actual or extreme length is greater than the virtual length, $\frac{1}{2}\lambda$.

6. A broadening at both ends decreases the frequency of oscillation, i. e., the actual or extreme length is less than the virtual length, $\frac{1}{2}\lambda$.

7. If an oscillation is caused by two opposing straight walls of different lengths, the rise and fall upon the longer will not be confined to the region lying opposite the shorter wall, but will extend some distance beyond.

8. Suppose a stationary oscillation to exist in a canal communicating with a tided sea; let the length of the canal lie between 0 and $\frac{1}{4}\lambda$, then at the time of high water outside it is high water throughout the canal (e. g., many Alaskan canals). If the length lie between $\frac{1}{4}\lambda$ and $\frac{3}{4}\lambda$, it is low water for a distance of $\frac{1}{4}\lambda$ from the head at the time it is high water outside (e. g., Irish Sea, node at Courtown; English Channel, node at Christchurch). If the length be equal or nearly equal to $\frac{1}{4}\lambda$, then the horizontal motion at the mouth, instead of the vertical motion, determines the time of tide within. This tide will be three hours later than the tide outside (e. g., the Gulf of Maine).

9. Whenever a rise and fall apparently necessitates a discontinuity in height, as at an incomplete boundary, a wave will generally be propagated outward, with velocity due to depth, from the discontinuity; or a dependent (stationary) oscillation will be set up in and beyond the openings.

10. If we can see that a reflected wave must travel in a direction nearly opposite to that of the direct wave, then there must result a more or less considerable stationary wave dependent upon the degree or amount of the reflection.

11. A good reflection occurs where the cross section changes much within a small fraction of a wave length.

12. If the region adjacent to an oscillating area consist of a bay or gulf, with numerous branching arms of different dimensions, and if it has various depths or has openings into other bodies of water, the wave will be almost wholly progressive, at least for a considerable distance up. For no large regular reflected wave will return resembling the direct wave as it entered.

13. In a strait, not too short, connecting the ocean with a sea which has neither tides of its own nor tides induced from without, the tide wave is stationary in its character.

14. In estimating the time of high water of a loop of a stationary wave having a broken boundary we should consider the tide at points situated some distance within the boundary; that is, not too near the openings. As the openings are approached the time becomes later, supposing the wave to be freely transmitted beyond, either into an infinite sea or into one which does not reflect. The larger the opening the greater this delaying effect. E. g., Cape Horn, Iceland Channel, Baffin Bay, southwestern Africa, and off Senegambia.

15. For an island situated in an oscillating area, but not too near a nodal line, it may be high or low water upon the side facing the nodal line earlier than in the sea surrounding the island. Similarly, for a cape extending far into the area. E. g., Kahului, Maui Island, Hawaii; Apia, Samoan Islands; Cape Farewell, Greenland.

The principal semidaily movements of the oceans are here supposed to be due to the following systems which are outlined upon the accompanying chart of the world (pages 104 and 105). Along the boundaries the rise and fall may be little or much, all depending upon the case considered. The Roman numerals indicate, unless otherwise stated, the cotidal hours; i. e., the Greenwich lunar times of the semidaily high water. The systems may be designated thus:

1. North Atlantic; 2. South Atlantic; 3. North Pacific; 4. South Pacific; 5. North Indian; 6. South Indian; 7. South Australian (solar).

The North Atlantic system is in the form of a broad band extending from the northeastern coast of Brazil northeasterly $\frac{1}{2}\lambda$, thence northwesterly $\frac{1}{2}\lambda$ to Greenland and Baffin Bay. According to this the range of tide should be especially great off Morocco and Portugal. The cotidal hour at either end should be VIII, and for the angle it should be II. These statements agree fairly well with observation, if we keep in mind lemmas 4, 8, 9, and 14. The tides of northern Portugal, Spain, and France (and therefore for Great Britain), are increased by the fact that this continental coast line in a general way opposes the American coast extending from Newfoundland to Cape Farewell by way of Davis Strait, the distance between the two coasts being about $\frac{1}{2}\lambda$.

The South Atlantic system bears a fanciful resemblance to a branching tree, the trunk very broad and $\frac{1}{2}\lambda$ in length extending from the Antarctic Continent to about latitude 27° S. One branch extends northeasterly $\frac{1}{2}\lambda$ to Baluchistan and India; another branch extends northwesterly λ to the Atlantic coast of the United States; a third branch extends about west-northwest $\frac{1}{2}\lambda$ to the eastern coast of Brazil.

Three of the nodal lines are capable of some verification by observation; one sets out from near Guadeloupe Island, another passes near Ascension, another we suppose to pass north of Bouvet Island. For the Antarctic Continent, the coast of Baluchistan (save for the effect of the Indian systems), and Brazil, the cotidal hour should be VI. For the vicinity of South Africa (save for the effect of the South Indian system), and for the east coast of the United States, the hour should be XII. These remarks are in fair accord with observation, bearing in mind lemmas 4, 8, 9, and 14; but no observations have yet been made upon the Antarctic Continent.

The North Pacific system consists of two parts; a triangular region between North America and Asia, and a trapezoidal one extending from the southern side of the triangle to the coast of Chile, a distance about equal to λ. The acute angles of the triangle fall at Colombia and the Philippine Islands; the obtuse angle at Alaska. If regarded as consisting of two right triangles, the right angles may be supposed to fall south of the Hawaiian Islands. According to the theory of the oscillation of a plane right triangle whose oblique angles are 30° and 60°, the rise and fall at these angles should be three times as great as that at the right angle. The nodal lines divide the hypotenuse into three equal parts. The magnitude of the tide of the North Pacific has been found from observation to vary somewhat in accordance with this scheme. The cotidal hours for the entire system (triangles and trapezoid together) is not far from III and IX as indicated on the chart. This agrees fairly well with observation.

The South Pacific system comprises a belt extending from southern Chile and Graham Land westerly and northwesterly a distance nearly equal to λ, thence northeasterly a distance nearly equal to λ to the coast of southern and Lower California. If we add to the L-shaped figure just described the space inclosed between it and the American coast, we have, roughly speaking, a sector of a circle. The free period of a circular sector is obtained by using for λ about 0.90 of the radius. The two nodal circles have for radii 0.34 and 0.79 of the radius of the sector. The rise and fall at the center of a circle should be more than thrice that at the circumference. While it is not probable that the sector is perfect enough to be very satisfactory, it seems likely that it does modify the positions of the nodal lines of the L-shaped figure and lengthen its period of oscillation; also that it helps to explain the considerable range of tide north of New Zealand. The cotidal hour for the extremities and angles of the L should be VI and this is indicated by observation. Between the two nodal lines (or circles), other causes aside, the hour should be XII. Observation seems to point to this in a general way.

The North Indian system consists of a simple or canal-like area extending from the northwestern coast of Australia, a distance λ to the coast of Somali and Arabia. By theory, the cotidal line at either end should be III, and between the nodal lines it should be IX. Moreover the Bay of Bengal being a dependent fractional area whose length lies between

$\frac{1}{2}\lambda$ and $\frac{1}{2}\lambda$, the cotidal hour above the nodal line should, by lemma 8, be III. These requirements are in general accord with observation.

The South Indian system consists of a simple area extending from the south coast of Australia southwesterly $\frac{1}{2}\lambda$ to where it is supported by the Antartic Continent; thence northwesterly $\frac{1}{2}\lambda$ to Madagascar and South Africa. The cotidal hour, at either end, should be III. Moreover the nodal line falling near Cape Leeuwin prevents there being any sensible semidiurnal tide at Freemantle on the western coast. These statements accord well with observation. It remains to be observed whether or not the cotidal hour where this area rests against the Antartic Continent is IX.

The South Australian system consists of a simple area extending from the Antartic Continent, a distance of about $\frac{1}{2}\lambda$ (solar) to the south coast of Australia. The solar cotidal hour for the north end should be VI and for the south end XII. Observations at Port Adelaide show that the solar wave is there large, and that the age of the tide is considerable as this theory would imply. But there is need of more information about the tides along this coast of Australia.

In comparing the above schemes with the results of observation, particular attention should be paid to the cotidal lines shown in Berghaus' Physikalischer Atlas (1892) and to the results of harmonic analyses, rather than to the older cotidal charts.

NOTES BY THE EDITOR.

THE MEASUREMENT OF RADIANT HEAT.

The Editor frequently receives suggestions or inquiries relative to methods of measuring the heat received by the earth from the sun. This is undoubtedly the most important and fundamental problem of meteorology; the solar heat is to the atmosphere what the fire is to the steam engine, and the time will come when mathematicians and physicists will be able to give a full account of the work done by this source of energy. Perhaps the first apparatus that gave any idea of the amount of heat received from the sun was that invented by Sir John Herschel and called an actinometer. This was improved upon by Pouillet, whose pyrheliometer has long been a standard method of measuring solar heat. During recent years different forms of improved apparatus have been developed by Crova, Violle, Maurer, Chwolson, and, perhaps best of all, by Knut Angström, of Upsala. In all of these it is clearly recognized that the intensity of radiation, namely, the quantity of heat received per square unit per minute of time, is not indicated by any of the numerous forms of apparatus in which a thermometer exposed to the sunshine becomes heated to some high but stationary temperature. This so-called static method of measurement must be replaced by the so-called dynamic method in which the thermometer or its equivalent is exposed to the sunshine and then completely shaded from it alternately several times, so that we may measure the rate of heating under the influence of all sources of heat, including the sunshine, and again the rate under the influence of all sources except sunshine.

As Angström's apparatus is to be recommended, we submit the following description for the guidance of our correspondents.

In Angström's electrical compensation pyrheliometer, as described by him in 1893, and again in 1899 (Wiedemann Annalen, vol. 67, page 633–648) we have, after continued use for several years, an instrument adapted to a wide range of work. It consists of two thin exactly similar and equivalent metal strips, each blackened on one side. One of these is exposedto the radiation that is to be measured, the second is thoroughly protected from this and other obnoxious radiations but is warmed by the passage of an electrical current. If the electrical current is so regulated that both metal strips are equally warmed, then the quantity of heat given to the first by radiation is equal to that produced in the second by the electric current; this equality in the temperatures is determined by means of thermo-electric elements attached to the back of each strip. If q is the energy of radiation per second, per square centimeter, expressed in gram calories, b the breadth of the metal strip, a the power of absorption per unit length of the strip, on its lampblack side, r the resistance of the unit length of the strip to the electric current, i the intensity of the electric compensation current, then we have the relation $b\ a\ q = ri^2 / 4.18$, whence we obtain the desired energy of radiation in gram calories $q = ri^2/4.18\ b\ a$ in gram calories per second per square centimeter, or $q = 60\ ri^2/4.18\ ba$ in gram calories per minute per square centimeter. By this method we avoid any correction for radiation, convection, or reduction, since these sources of error are assumed to be the same for both strips on account of their equality as to size and temperature. We also need to determine the constants r b and a only once; each determination of the radiation needs only one observation of the intensity of the current, i, in order to obtain the radiation in absolute measure. As r varies slightly with temperature this variation must also enter into the calculation. The two similar metal strips must, of course, be prepared with the greatest care. The blackening of one side of each strip gives to the edges a slight roughness so that an error of 0.01 mm. in the width can scarcely be avoided; this introduces an uncertainty of one-half of one per cent in the results by the apparatus used by Angström. The thermo-electric element is at the back of the metal strips. In order to secure symmetry in the radiation from the rear surface the backs of the strips are covered with black varnish. The fronts are covered with lampblack laid over a thin deposit of zink and platinum chloride. The resistance of the strips to electric currents is determined by the use of Lippman's capillary electrometer. The most important and difficult constant to determine is the power of the lampblack side of the strip to absorb radiant heat. Angström's investigations show: (*a*) That the absorptive power of platinum black is only slightly increased by covering it with lampblack, but is more uniform than lampblack for different wave lengths. (*b*) The surface that has this double covering has an absorptive power that is slightly selective in that it increases with the increase of wave length. (*c*) Its average absorptive power for solar radiation increases from 98.3 to 98.8 per cent with the increase in the thickness of the layer of lampblack. (*d*) If we assume the absorptive power of such surfaces to be the same for all wave lengths and equal to 98.5 per cent, then the error thereby introduced into the determination of the intensity of the radiation would not exceed one-half per cent. It is best to use two different galvanometers for the temperature equality and for the current intensity, respectively.

Laboratory experiments show that different instruments give results that agree closely, and do not change with time, and that those with the compensation pyrheliometer are accurate to within one-half of one per cent. In 1895 and 1896 Professor Angström determined the absolute intensity of the solar radiation by observations with a special light and portable apparatus on the summit of the Peak of Teneriffe. The full report of this important work has not been published, but from